I. C. 825.

[Form April 1, 1881.]

CINCINNATI SOUTHERN RAILWAY.

SPECIFICATIONS FOR BRIDGES AND VIADUCTS OF IRON AND TIMBER.

10-20-84.

GENERAL.

PLANS AND STRAIN-SHEET.—All structures will be built in accordance with the general plans exhibited.

Bidders must submit with their proposals, complete strain-sheets for the structures, and plans showing the form and size of each typical member.

The strain-sheets must show for each member the total strain sustained, and the dimensions and area of cross-section, also the dead-weight assumed in the calculation and the resulting weight of the truss, which must not be ~~less~~ more than the dead-weight assumed.

Complete detail drawings must be submitted for approval of the Engineer, by the contractors, before commencing work.

A copy of every approved strain-sheet and drawing will be furnished without charge by the contractor for file in the Engineer's office, before commencing the work of erection.

Provision must be made in the designing of all structures for the free expansion and contraction of all parts, corresponding to a variation of 150 degrees Fahrenheit in the temperature.

MATERIAL.—Unless otherwise specified, all parts of iron bridges and viaducts shall be of wrought iron, except the floor timbers as shown in the standard plans of roadway annexed. Cast iron may be used in minor details.

GENERAL DIMENSIONS.—Through bridges must not be less than fourteen (14) feet in width in the clear between trusses, and eighteen and one-half (18½) feet in height in the clear, measuring from the top of the rail.

LOADS.

All parts of the structure must be proportioned to sustain the strain produced,

1st—By the weight of the structure itself.

2nd—By the rolling-load specified, moving at a speed of thirty miles per hour, and considered in positions and conditions (standing, moving and stopping) giving the greatest results.

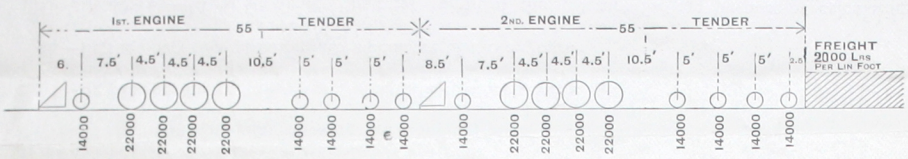
3rd—By the specified wind-pressure, giving the greatest results.

4th—By the effect of a variation in temperature of 150 degrees.

DEAD-LOAD.—In determining the total weight of the structure for the purpose of calculating strains, the weight of the iron shall be assumed at $\frac{1}{3}^{0}$ lbs per lineal foot of bar of one square inch area.

The weight of the timber shall be assumed at 4½ lbs per foot, B. M., and an addition of 90 lbs per

ROLLING-LOAD.—The rolling-load consists of two locomotives, followed by a train-load averaging 2,000 lbs per lineal foot, as shown in following diagram.



To provide for the effect of impact all such parts of the structure as are liable to be subjected to sudden strains or vibrations, shall be calculated with additions to the above specified rolling-load, as follows:

Floor-beam hangers, and rivetted connections of stringers and floor beams, - - 50 per cent.

Stringers, floor-beams, counter-ties, middle-ties and posts, trestle-posts and

Truss members of spans	30 feet long and less, - - - -	25 per cent.
" " " "	30 feet to 45 feet long, - - - -	20 " "
" " " "	45 " " 60 " " - - - -	15 " "
" " " "	60 " " 75 " " - - - -	10 " "

WIND-PRESSURE.—Wind strains will be calculated:

1st—For a wind-pressure of 30 lbs. per square foot on the exposed surfaces of both trusses, and on a moving train-surface averaging 10 square feet per lineal foot of track.

2nd—For a wind-pressure of 50 lbs. per square foot on the exposed surfaces of both trusses.

And the greatest results will be assumed in the proportioning of parts.

FRICTION.—The co-efficient of friction of wheels sliding on the rails will be assumed at $\frac{2}{10}$.

DIMENSIONS OF PARTS.

LIMITS OF STRAINS PER SQUARE INCH.—All parts of the structure must be so proportioned that the combined effect of all the loads specified, except the wind, shall not cause the strain per square inch to exceed the following maximum limits:

FOR IRON.	For tension, - - 10,000 lbs.	FOR WOOD.	For tension, - - - - - 1,000 lbs.
	For compression, - - 8,000 lbs.		For compression in direction of fibres, 1,000 lbs.
	For shearing across fibres, 7,500 lbs.		For shearing along fibres, - - 100 lbs.

The strain in compression must be reduced with the ratio of diameter to length of post, according to the following formula:

	IRON.	TIMBER.
For posts with square bearings, and for top flanges of built beams between stiffeners, - - - - -	$R=\frac{1}{5}\frac{38000}{1+\frac{l^2}{36000\,r^2}}$	$R=\frac{1}{7}\frac{7000}{1+\frac{l^2}{3000\,r^2}}$
For posts with square bearing at one end, and a pin bearing at the other, - - - - - - - -	$R=\frac{1}{5}\frac{38000}{1+\frac{l^2}{24000\,r^2}}$	$R=\frac{1}{7}\frac{7000}{1+\frac{l^2}{2250\,r^2}}$
For posts with pin bearings, - - - - -	$R=\frac{1}{5}\frac{38000}{1+\frac{l^2}{18000\,r}}$	$R=\frac{1}{7}\frac{7000}{1+\frac{l^2}{1500\,r^2}}$

Where R represents the strain per square inch of cross-section,

l the length of post in inches,

r the least radius of gyration of the section.

On pin and rivet holes the maximum pressure allowed will be 15,000 lbs. per square inch of the diameter by length of bearing surface.

For bending, the maximum shall be for wrought iron: On outside fibers in tension, 10,000 lbs; on outside fibers in compression, 8,000 lbs., except for pins coupling members closely packed together, where a strain of 15,000 lbs. per square inch on outside fibers will be allowed.

For timber, the maximum allowed on outside fibres shall be 1,000 lbs.

WIND-STRAINS.—An addition of 25 per cent. to the foregoing specified limits of strain will be allowed for wind-strains.

EYE-BARS AND UPSET RODS.—The eye and threaded parts of all bars and rods must not be less in strength than the body of the bar. The area of the section through center of eye, perpendicularly to the direction of the bar, must not be less than given in the following table:

Ratio $\frac{\text{Diam. of Pin.}}{\text{Diam. of Bar.}}$	Ratio $\frac{\text{Area of eye through Center.}}{\text{Area of Bar.}}$	
	For Hydraulic forged weldless bars.	For hammer forged welded bars.
Less than 1.00	1.50	1.40
1.00	1.50	1.50
1.25	1.60	1.60
1.50	1.80	1.67
1.75	2.00	1.71
2.00	2.20	1.75

The area of the section at base of thread must exceed sectional area of rod by not less than 17 per cent.

COMPRESSION-MEMBERS.—The thickness of metal in compression shall not be less than one-~~sixteenth~~ thirtieth ($\frac{1}{30}$) of the distance between supports in line of strain, and one ~~sixteenth~~ thirtieth ($\frac{1}{30}$) of distance between supports at right angles with line of strain, nor less than one-quarter ($\frac{1}{4}$) inch when both faces are accessible for painting, and five-sixteenths ($\frac{5}{16}$) inch when one face only is accessible.

Ratio of length to diameter must not exceed 45.

In built posts and struts the segments must all be of one length without break, and must be rigidly rivetted together to act collectively as one solid body.

The sectional area of rivets in one segment in the distance of two diameters from the end, must not be less than the sectional area of the segment.

Where lattice-work is used, the distance between rivets must not be ~~less~~ more than length of segment of equal strength per square inch as the column itself, and the lattice-bars must be calculated as struts resisting the difference in the strengths per square inch of the column and that of its weakest segment acting singly without lateral supports.

PINS AND RIVETS.—Pins will be proportioned to resist the bending as well as the shearing forces acting upon them. The limits of strain specified for shearing and for the pressure on bearing-surface of holes will determine the size and number of rivets. The aggregate area of rivets shall not be less than the sectional area of the joined pieces.

I BEAMS.—Must be so proportioned that the top and bottom flanges will resist the bending moments without considering the web, and the web will resist the shearing forces without considering the flanges.

CONNECTIONS AND ATTACHMENTS.—Of all members must be of strength at least equal to that of the member or members which they are designed to connect. This shall be demonstrated by testing

BED-PLATES AND FRICTION-ROLLERS.—Bed-plates must be so proportioned that the maximum pressure per square foot on masonry will not exceed 25,000 lbs. The pressure per lineal inch on friction-rollers must not exceed $\sqrt{540{,}000d}$. (d) being the diameter of rollers in inches.

WORKMANSHIP AND DETAILS OF CONSTRUCTION.

All workmanship must be first class in every particular.

All members must be free from twist and bends.

ABUTTING JOINTS must be planed or turned in a plane perpendicular to the line of strain, and shall be in contact throughout.

PIN-HOLES must be bored, not punched, exactly perpendicular to the ceuter lines of strain, and not more than one-fiftieth ($\frac{1}{50}$) inch larger than the diameter of the pin.

EYE BARS working together must be straightened before boring. They must be bored in one operation, piled on each other, at the same temperature.

PINS must be turned true to size and straight. They must be turned down to a smaller diameter at the ends for the thread and driven in place with pilot-nut when necessary to save the thread. There must be a washer under each nut.

No discrepancy in length of pins through the bearing parts will be allowed.

The several members attaching to the same pin shall be held and closely packed in position by filling-rings between them.

RIVETTED-WORK.—All joints in rivetted-work shall be square and truly dressed and in contact throughout. They must be fully spliced, no reliance being placed upon the contact of abutting parts.

The web of plate-girders must be spliced by a plate on each side.

Rivet holes must be accurately spaced and punched and fit exactly opposite to each other without reaming. The space between the edge of a piece and the edge of rivet holes shall be such that the iron will not crack nor split by punching.

Rivets when driven must completely fill the holes.

Rivet-heads must be full size, well formed and concentric to the holes.

No loose rivets will be allowed.

COUNTER-RODS and all other members requiring adjustment must be provided with adjusting screw-threads and nuts.

WASHERS AND NUTS must have a uniform bearing.

All nuts must be easily accessible with a wrench for the purpose of adjustment and must be effectively checked after the final adjustment.

All parts working together as parts of one member of the truss must be equally strained.

Tensile strain must be avoided in a transverse direction to the fibers of the iron and shearing strain in a direction parallel to the fibers of the iron.

FLOOR.—The roadways, unless otherwise specified, will be in accordance with the adjoining diagrams designed for panels 15 feet long, sizes of stringers and floor-beams being proportioned to the length of panel.

The cross ties shall be spaced twelve inches from center to center. They shall be locked longitudinally by the guard timbers notched one inch over each tie, and transversely, where iron stringers are used, by the projection above top flange of the web of the iron stringer penetrating one inch into narrow slits in the bottom of the ties.

Every third tie shall be bolted to the stringers and guard timbers by ¾ inch bolts.

All intermediate ties shall be fastened at each end to the guard timbers with a ⅝ inch bolt.

The stringers must be securely fastened to the floor beams.

The wood stringers made of pieces of two panel lengths, packed together as shown, must be covered with No. 15 galvanized iron projecting 2 inches, at least, on each side.

The ties must be carefully adzed in position to the proper level to afford a true and uniform bearing for the rails.

All framing must be done to a close fit and in a thorough and workman-like manner.

No open joints or filling-shims will be allowed.

All surfaces where wood touches wood must be thoroughly painted, before being put together, with hot coal-tar, properly thickened with lime.

All void spaces between tenons and mortises must be thoroughly filled with the same paint so as to be water-proof.

Angle-blocks, tubes, washers, parting- and packing-blocks, brace-shoes and bridge-seats for wooden bridges, must be of cast iron and of approved pattern.

Splicing-clamps must be entirely of wrought iron.

High hexagonal nuts, dressed on both ends, must be used for truss rods. No round-headed bolts will be allowed. All bolts must be provided with washers under head and nut.

The use of more than one washer under the nut to make up for deficiency in length of thread will not be allowed.

PILES must be straight, properly pointed, and have all the bark peeled off. They shall, if required, be shod with cast or wrought iron shoes of approved form and size, as may be determined by the Engineer,

In driving they shall be capped with suitable iron rings to prevent splitting if necessary.

They shall be driven with a hammer of suitable weight and fall; the fall being regulated by tripping the hammer, if necessary, to prevent splitting.

All piles must be of such length and driven to such depth as may be directed by the Engineer.

All piles injured in driving or driven out of place or line shall be cut off and another one driven in its place, and the pile thus replaced shall not be paid for.

Piles will be paid for by the lineal foot, counting only the number of feet of piles left in the structure after completion.

CAMBER.—The camber measured on the center line of chords for wooden bridges, and on the center of pins of chords for iron bridges, must not be less than one six-hundredth ($\frac{1}{600}$) of the span for wood, and one twelve-hundredth ($\frac{1}{1200}$) of the span for iron trusses. The camber line must not deviate from an arc of a circle more than one-quarter ($\frac{1}{4}$) of an inch at any place.

The track stringers from the center to each end of the span must be so shimmed up as to reduce the camber in the track to one-half of the camber in the truss and make it a true arc of a circle.

TRACK ON CURVES.—On bridges and viaducts on curves the outside rail will be elevated one-half inch for every degree of curvature, unless otherwise specified.

ANCHORAGE.—All bridges and viaducts must be sufficiently anchored to the masonry to resist displacement by the strongest wind specified.

All the necessary drilling and dressing of masonry must be done and all the necessary fastenings and anchorage put in by the contractor without extra allowance.

APPROACHES.—The contractor must furnish and put in place the necessary wall-plates, cross-ties, and guard timbers over piers and abutments of all structures and furnish and put in the standard aprons at each end of the structure so as to connect the roadway of the structure with the graded road-bed. This work will be paid by the thousand ft. B. M., at the price named in the proposal. This price must cover the cost of labor and material, including iron in bolts, washers, spikes, &c.

QUALITY OF MATERIAL.

WROUGHT IRON must be tough, ductile, uniform in quality and must have a limit of elasticity of not less than 26,000 lb. per square inch.

When tested in specimens of uniform sectional area of at least ½ square inch for a distance of 10 inches, it must stand without breaking, the following tensile strain and elongation in the distance of 6 inches:

For bar iron,	52,000	lbs.	per	square	inch.	Elongation,	20	per	cent.
" all shape iron	50,000	"	"	"	"	"	15	"	"
" plates,	48,000	"	"	"	"	"	10	"	"

The iron shall bend cold without fracture:

180 degrees for bar iron.
135 " " shape "
90 " " plate "

Rivets and pins shall be made from the best double-refined iron.

All iron must be free from injurious seams or flaws, blisters, buckles, cinder-spots, and imperfect edges.

CAST IRON must be of the best quality of tough, gray metal. A cast bar five feet long, one inch square, 4 feet 6 inches between supports, shall bear without breaking, a weight of 550 lbs. suspended at the center.

Castings must be smooth, well shaped, free from air-holes, cracks, cinders and other imperfections.

TIMBER.—The timber shall be of the sound heart-wood of the white or long-leaf yellow pine, white oak or cypress, as may be determined by the Engineer for each particular member. It shall be sawed true and out of wind, full size, free from wind-shakes, large or loose knots, decayed, brash or sap-wood, worm-holes or any defect impairing its strength or durability.

All timber must be inspected and accepted by the Engineer before used.

INSPECTION AND TESTS.

An expert inspector appointed by the Engineer will inspect the material, supervise the work at the shop and the work of erection and all the tests to be made. All parts of the structure must be inspected and accepted by him before shipment.

All facilities for inspection shall be furnished by the contractors.

The contractor shall make, free of charge, all the specimen tests required by the inspector, and shall test also without charge, all the tensile members of the structure to 20,000 lbs, per square inch.

The extension under this strain of each member shall be accurately measured, and the modulus of elasticity deduced therefrom.

All bars showing a permanent set after this test or a variation of more than 10 per cent. in its modulus as compared with the moduli of all other bars working with it in the same member of the structures shall be rejected.

Full sized parts of the structure may be tested at the option of the engineer, and shall be paid for at cost less its scrap value if it proves satisfactory. If the test is not satisfactory the contractors shall receive no compensation.

Before the final estimate is paid a thorough test of the structure will be made by the Engineer, by loading each span with such rolling-load or its nearest equivalent obtainable, at such rate of speed as described under the head of "loads," and also by causing the load to remain on each span for the space of one hour or more. Each span must not deflect under such a load more than one nine-hundredth ($\frac{1}{900}$) of its length, if of wood, and one eighteen-hundredth ($\frac{1}{1800}$) of its length, if of iron, and each span must return to its original camber when the load is removed.

PAINT.

All iron before leaving the shop must be soaked in boiled linseed oil. All planed or turned surfaces must be coated with white lead mixed with tallow.

All inaccessible surfaces must be painted before being put together with two coats of red lead or other metallic paint approved on sample by the Engineer. After erection, the entire structure, excluding timbers, but including the galvanized iron on wooden stringers, must be painted with two coats of the same paint.

No painting must be done in wet or freezing weather.

RIVER NAVIGATION AND RUNNING OF TRAINS.

When rivers are navigable they must at all times during the construction and erection of the structure be kept free for navigation.

All coffer-dams, staging and other obstructions must be removed by the contractor when directed by the Engineer, leaving the river entirely unobstructed except the actual space occupied by the masonry.

The contractor shall so conduct all his operations as not to impede the running of trains or the operation of the road.

He will take down and out of the way, all the staging used in the erection, and also the old bridge if any exists.

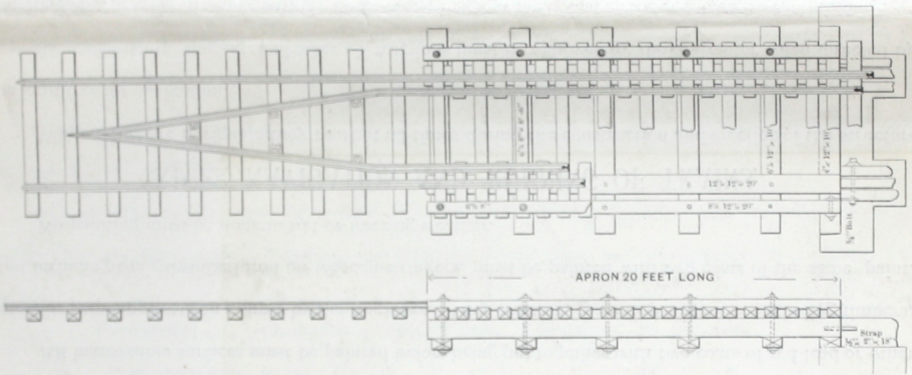
RISKS.

The contractor shall assume all risks from floods and storms and casualties of every description, and must furnish all materials and labor incidental to, or in any way connected with the manufacture, transportation, erection and maintenance of the structure until its final acceptance.

The word "Engineer" shall mean the "Consulting and Principal Engineer," unless otherwise

CINCINNATI SOUTHERN RAILWAY.

Standard Approach for Bridges.



Standard Roadway for Bridges.